PALM KERNEL SHELL AS PARTIALLY REPLACEMENT OF FINE AGGREGATES IN CONCRETE

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ABSTRACT

This final year project discussed mainly about the feasibility of using the palm kernel shell as a partial replacement of fine aggregates in concrete. This studied were used the different percentage of palm kernel shell as a partial replacement of fine aggregates in concrete at 1%, 2%, and 3% by volume of sand. Palm kernel shells are derived from the oil palm tree (elaeis guineensis), an economically valuable tree because of its oil. Palm kernel shells have been used as aggregates in light and dense concretes for structural and non-structural purposes. Palm kernel shell were obtained from the Lepar Hilir palm oil mill and sieved with size between l.5mm to 2.36mm. The objectives of this final year project are to determine the workability, compressive strength and also flexural strength of concrete when adding with 1%, 2% and 3% of palm kernel shell as a replacement of fine aggregates in concrete. All of the testing were followed the British standard. The workability of concrete were tested by using slump test to check the consistency of freshly made concrete. For compressive strength total of 27 cubes with size 150mm x 150mm x 150mm were used to determine the compressive strength of concrete when replace with 1%, 2% and 3% of palm kernel shell as a replacement of fine aggregates in concrete. Then for flexural strength total of 27 beams with size 100mm x 100mm × 500mm were used to determine the flexural strength of concrete when replace with 1%, 2% and 3% of palm kernel shell as a replacement of fine aggregates in concrete. Compressive and flexural strength were conducted at 7 days, 14 days, and 28 days to get the strength of concrete. All of the testing were compared with normal concrete. As the result were obtained, it can concluded that replacement of palm kernel shell with 1% replacement had a probability to use as a sand replacement in construction industry.

ABSTRAK

Projek ini merangkumi kemungkinan penggunaan tempurung buah kelapa sawit sebagai bahan ganti pada pasir di dalam konkrit. Kajian ini dijalankan menggunakan beberapa sampel yang mengandungi peratusan tempurung buah kelapa sawit yang berbeza sebagai pengganti pasir di dalam bancuhan konkrit. Peratusan gentian yang digunakan adalah 1%, 2%, dan 3% daripada jumlah isipadu pasir. Tempurung buah kelapa sawit berasal dari pokok kelapa sawit (Elaeis guineensis), iaitu pokok yang berharga dari segi ekonomi kerana minyaknya. Tempurung buah kelapa sawit telah digunakan sebagai agregat dalam konkrit ringan dan padat untuk binaan struktur dan bukan struktur. Tempurung buah kelapa sawit diperolehi dari kilang pemprosesan kelapa sawit yang terletak di Lepar Hilir dan disaring dengan saiz antara l.5mm sehingga 2.36mm. Objektif projek tahun akhir ini adalah untuk menentukan kebolehkerjaan, kekuatan mampatan dan kekuatan lenturan konkrit apabila diganti dengan 1%, 2% dan 3% daripada tempurung buah kelapa sawit sebagai pengganti pasir di dalam konkrit. Semua ujian yang dijalankan mengikut piawaian *British Standard*. Kebolehkerjaan konkrit telah diuji dengan menggunakan ujian kemerosotan untuk menyemak ketekalan konkrit yang baru dibuat. Untuk kekuatan mampatan sebanyak 27 kiub dengan saiz 150mm x 150mm x 150mm telah digunakan untuk menentukan kekuatan mampatan konkrit apabila diganti dengan 1%, 2% dan 3% daripada tempurung buah kelapa sawit sebagai pengganti pasir di dalam konkrit. Kemudian, untuk kekuatan lenturan sebanyak 27 rasuk kecil dengan saiz 100mm x 100mm × 500mm digunakan untuk menentukan kekuatan lenturan konkrit apabila diganti dengan 1%, 2% dan 3% daripada tempurung buah kelapa sawit sebagai pengganti agregat halus dalam konkrit. Kekuatan mampatan dan lenturan telah dijalankan pada 7 hari, 14 hari, dan 28 hari. Semua uji kaji yang dijalankan dibandingkan dengan konkrit yang biasa. Berdasarkan keputusan yang diperolehi, didapati bahawa penggantian tempurung buah kelapa sawit dengan penggantian 1% mempunyai kebarangkalian yang positif untuk digunakan sebagai pengganti pasir di dalam industri pembinaan.

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LIST OF SYMBOLS

Mpa	MegaPascal
mm	Milimeter
kg	Kilogram
kg/m^3	Kilogram per meter cubic
kg/cm^2	Kilogram per centimeter square
mm/s	Kilogram per second
°C	Degree Celcius
kN/mm^2	KiloNewton per milimeter square

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Concrete is a composite static material containing of aggregates, water and cement. Concrete has been created a long time ago for constructing various structures around the world, such as, buildings, bridges, dams and etc. Nowadays, some countries are undergoing rapid infrastructure development, thus increase the demand of concrete. As an example, the mass rapid transit project that are being construct in Malaysia required to use mass volume of concrete. The cost of concrete at these days are currently so high probably because of the increasing of demand. Besides, the strength of concrete is important to avoid the natural disasters, such as, earthquake, tsunami, tornadoes and flooding which may cause the people to get hurt or death. So, to overcome this problem, the cheap locally available waste material need to be adopt.

Nowadays, the construction industries have been searching the alternatives product that can help to minimize the cost of concrete. There are some waste material that have been identified which can help to reduce the volume of materials in concrete, such as, coconut shells, egg shells, and etc. Among of the waste material that have been identified, there are known to have good characteristic in increase the strength of the concrete which results in reducing the amount of waste and materials in concrete.

Oil palm is truly a golden crop of Malaysia. Oil palm is grown for its oils. As vegetable oil seed crop, the oil palm is an efficient converter of solar energy into biomass. Besides being a prolific producer palm and kernel oil, it also generates a number of residues and by product. The residues of oil palm industry are from the field and mill.

Palm kernel shells are one of the wastes from palm oil industry, which have long been used as fuel in boiler to produce steam and electricity for mill processes. Palm kernel shell is the hard shell of the oil palm fruit seed that is broken to take out the kernel used for extracting palm oil. Thus, it is the by-products of palm oil processing during which the palm oil is extracted.

1.2 PROBLEM STATEMENT

For thousands of years, sand and gravel have been used in the construction of roads and buildings. Today, demand for sand and gravel continues to increase. Mining operation, in conjunction with cognizant resource agencies, must work to ensure that sand mining is conducted in a responsible manner. Excessive instream sand and gravel mining causes the degradation of rivers and lowers the stream bottom, which may lead to bank erosion. Besides, depletion of sand in the streambed and along coastal areas causes the deepening of rivers and estuaries, thus enlargement of river mouths and coastal inlets. In addition, sand mining also lead to increase of sea level, saline-water intrusion from the nearby sea, and loss to the system.

To overcome this problem, this study will studied the feasibility of using the palm kernel shell as a partial replacement of fine aggregates to reduce the problems.

1.3 OBJECTIVES OF STUDY

i. To determine the workability of concrete when replace with 1%, 2% and 3% of palm kernel shell as a replacement of fine aggregates in concrete.
ii. To determine the compressive strength of concrete when replace with 1%, 2% and 3% of palm kernel shell as a replacement of fine aggregates in concrete.
iii. To determine the flexural strength of concrete when replace with 1%, 2% and 3% of palm kernel shell as a replacement of fine aggregates concrete.

1.4 SCOPE OF STUDY

Based on the objective, this study was conducted to determine the workability and strength of concrete when replace of fine aggregate with 1%, 2% and 3% of palm kernel shell. The scope of work mainly focuses on:

i. The experiments that will be conducted are slump test, compression test and flexural test.
ii. All the testing conducted will be follow British Standard.
iii. The compression test and flexural test will be conducted at 7 days, 14 days and 28 days to get the strength of concrete.
iv. The size of concrete cube will be 150mm x 150 mm x 150 mm.
v. The size of concrete beam will be 100mm x 100 mm x 500 mm.
vi. The cement-aggregates ratios will be 1:2:4, that means, one part of cement, 2 part of fine aggregates and 4 part of coarse aggregates.
vii. The size of palm kernel shell that used were passing sieve 2.36mm.
viii. The percentage of palm kernel shell that will be replace fine aggregate at 1%, 2% and 3% replacement by volume of fine aggregate.

1.5 SIGNIFICANCE OF STUDY

This research will be carried out to examine the feasibility of using the palm kernel shell as a partial replacement of fine aggregates in concrete. This research also determine the workability, compressive strength and flexural strength of concrete when replace with 1%, 2% and 3% of palm kernel shell as a fine aggregates in concrete in order to reduce the demand of sand and the effect of sand mining to ecosystems.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

There have been a number of advances in new concrete technology in the past ten years. There have been advancements made in almost all areas of concrete production including materials, recycling, mixture proportioning, durability, and environmental quality. However, many of these innovations have not been adopted by the concrete industry or concrete users. There is always some resistance to change and it is usually based on cost considerations and lack of familiarity with the new technology (Martin Dawson, 2010).

The latest new concrete technology is beginning to gain acceptance in the industry. Some of the more interesting new concretes are called high performance concrete (HPC), ultra high performance concrete, and geo-polymer concrete. They have significant advantages and little or no disadvantages when compared to standard concrete in use today (Martin Dawson, 2010).

High performance concrete usually contains recycled materials and thereby reduces the need to dispose of these materials. Some of these materials include fly ash, ground granulated blast furnace slag, and silica fume. But perhaps the biggest benefit of using some of these other materials is the reduction in the need to use cement, also commonly referred to as Portland cement. The reduction in the production and use of cement will have many beneficial effects. These benefits will include a reduction in the creation of carbon dioxide emissions and a reduction in energy consumption, both of which will improve the global warming situation. It is estimated that the production of cement worldwide contributes five to eight percent of global carbon dioxide emissions. In addition, the use of fly ash and furnace slag is usually cheaper than cement and they have properties that improve the quality of the final concrete (Martin Dawson, 2010).

Today's new concrete technology has produced new types of concrete that have live spans measured in the hundreds of years rather than decades. The use of fly ash and other by-product materials will save many hundreds of thousands of acres of land that would have been used for disposal purposes. Fly ash and other by-products from burning coal, are some of the most abundant industrial waste by-products on the planet. The elimination of burial sites for these waste by-products will translate into less risk of contamination of surface and underground water supplies. When compared to standard concrete the new concretes have better corrosion resistance, equal or higher compressive and tensile strengths, higher fire resistance, and rapid curing and strength gain. In addition, the production and life cycle of these new concretes will reduce greenhouse gas emissions by as much as 90% (Martin Dawson, 2010).

2.2 CONCRETE

Concrete is a composite inert material comprising of water, cement and aggregate. Often, additives and reinforcements are included in the mixture to achieve the preferred physical properties of the finished material. When these ingredients are mixed together, they form a fluid mass that was easily molded into shape. Usually, the concrete forms was a hard medium which binds the rest of the ingredients together into a durable stone.

Concrete is used more than any other man made material on the planet. The annual consumption of concrete is as much as two tones per person per year globally. Conventional concrete generally use widespread as the building construction materials on site which produced by following the instructions that usually consists of cement, sand or other common material as the aggregate, and often mixed with additives. Commonly conventional concrete have high self-weight due to the normal aggregates weight, use and cost for conventional production is really high.

Concrete has unlimited opportunities for innovative applications, design and construction techniques. Its versatility and relative economy in meeting wide range of needs has made it a very competitive building material. Both natural and artificial aggregates are used in the production of concrete in the construction industry. Fine and coarse aggregates which generally occupy 60% to 75% of concrete volume strongly influence concrete’s freshly mixed and hardened properties as well as its mix proportions and economy (A. Acheampong et al., 2013).

2.3 WASTE MATERIAL WITH PARTIALLY REPLACEMENT

Nowadays, there are some waste material which are being identified to be replace of fine aggregate in concrete production. As an example, according to D. Dahiru and J. Usman (2012), polymer waste material were identified to be partial replacement of fine aggregate in concrete production. Polymer waste material which are include polyethylene packing bags and pure water bags were collected from dump and processed to be fine aggregate with size 4.75mm. The result showed increase of 30% of polymer waste material leads to decrease of 53% compressive strength and decrease of 73.3% in tensile strength (D. Dahiru and J. Usman, 2012).

According to Sadoon Abdallah and Mizi Fan (2014), waste glass were studied to be replace of fine aggregate in concrete production. Waste glass which from used windows were used as a material of the study. The result showed the increase of percentage of replacement of waste glass would increase the compressive strength of concrete.

According to Sreekrishnaperumal Thanga Ramesh, et al. (2013), furnace slag and welding slag were studied to be replace of fine aggregate in concrete production. Furnace slag and welding slag were collected from local fabrication industries were used as a material. Normal concrete with zero replacement were used as a reference materials. The result showed the better performance of the concrete as a partial replacement of concrete. The compressive strength on seventh day of concrete cubes increases from 10% to 15% replacement of sand by welding slag than the reference materials. Similarly 10% of furnace slag showed an optimum strength of 21.1 N/mm2. The compressive strength on

28th day of concrete cubes increases from 5% to 15% of replacement of sand by welding slag than the reference materials. The optimum compressive strength of slag concretes has been found to be 41 N/mm2 for 5% welding slag and 39.7 N/mm2 for 10% furnace slag. The results show that 5% of welding slag and 10% furnace slag replacement with sand is very effective for practical purpose.

Then, according to Dr. Festus A. Olutoge, et al. (2012), palm kernel shell ash can be used as a replacement of cement. Palm kernel shell which were collected from palm oil mill were burnt and grinded into fine ash particles. Palm kernel shell ash were sieved through 45um sieve in order to remove any foreign material and bigger size ash particles. The result showed the concrete strengths were increased with the increase of curing age but were decrease with increasing percentage of palm kernel shell ash in concrete.

2.4 CEMENT

Cement is a binder, a substance that sets and hardens and can bind other materials together. Cements used in construction can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to be used in the presence of water. Non-hydraulic cement will not set in wet conditions or underwater, rather it sets as it dries and reacts with carbon dioxide in the air. It can be attacked by some aggressive chemicals after setting while the hydraulic cement is made by replacing some of the cement in a mix with activated aluminium silicates, pozzolanic, such as fly ash. The chemical reaction results in hydrates that are not very water-soluble and so are quite durable in water and safe from chemical attack. This allows setting in wet condition or underwater and further protects the hardened material from chemical attack (S. P. Arora, 2010).

There are many types of cements were available in markets with different compositions and for use in different environmental conditions and specialized applications such as ordinary Portland cement, rapid hardening Portland cement, low heat Portland cement, sulphate resisting Portland cement, pozzolanic cement, white Portland cement etc. As an example, ordinary Portland cement which is made by heating limestone with small quantities of other material such as clay, is the most common type of cement in general use around the world (S. P. Arora, 2010).

2.4.1 Chemical Composition of Portland Cement

Generally, the chemical compositions of Portland cement were varying due to supply from different manufacturers. Normally Portland cement contained the highest content of limestone, alumina and silica.

Table 2.1: General Composition Limits of Portland Cement

Oxide	Content, %
Calcium Oxide (CaO)	60 - 67
Silicon Dioxide (SiO_2)	17 - 25
Aluminium Oxide (Al_2O_3)	3- 8
Ferric Oxide (Fe_2O_3)	0.5 – 6.0
Magnesium Oxide (MgO)	0.5 – 4.0
Sodium Oxide (Na_2O)	0.3 – 1.2
Sulphur Oxide (SO_3)	2.0 – 3.5

Source: Lim Ooi Yuan, (2012)

A general idea of the composition of cement is presented in Table 2.1 (Lim Ooi Yuan, 2012). The content of limestone was the highest, followed by silica and alumina.as these chemical compositions are important for the formation of calcium silicate hydrate gel during hydration process. Besides, Portland cement also contain small content of iron, magnesium, and sodium.

2.5 COARSE AGGREGATES

Coarse aggregates are materials retained on 5mm (3/16 inches) test sieve and containing only so much finer material as permitted from the various sizes.

Table 2.2: Type of Coarse Aggregate and Source

Types	Source
Uncrushed gravel	From natural disintegration of rock
Crushed stone	From crushing of gravel or hard stone
Partially crushed gravel	Product of the blending of the uncrushed and crushed gravel

Coarse aggregate may be described into three major part which are uncrushed gravel, crushed stone or crushed gravel and partially crushed gravel when it is the product of bending of uncrushed and crushed gravel. Table 2.2 shows the different type of coarse aggregate and their source which all of them are from rock. According to Suryakanta, (2014), size coarse aggregate is described as graded aggregate of its nominal size. As an example, a graded aggregate of nominal size 20 mm means an aggregate most of which passes 20 mm sieve.

2.6 FINE AGGREGATES

Sand may be described into three major parts, which are natural sand, crushed stone and crushing gravel sand.

Table 2.3: Type of Fine Aggregate and Source

Type	Source
Natural sand	From natural disintegration of rock
Crushed stone sand	From crushing of hard stone
Crushed gravel sand	From crushing of natural gravel

Table 2.3 shows the different type of coarse aggregate and their source which all of the fine aggregate are from rock. According to Suryakanta, (2014), commonly, fine aggregate passed 4.75mm sieve and contains only so much coarser as is permitted by specification. Normally, river sand and crushed sandstone with fineness modulus of 1.78 were passed through a 2.36 mm sieve analysis. Commonly, material used are having maximum particle size with 2.36 mm diameter.

Figure 2.1: Natural Sand

Figure 2.2: Crushed Stone Sand

2.7 WATER CEMENT RATIO

The water–cement ratio is the ratio of the weight of water to the weight of cement used in a concrete mix and has an important influence on the quality of concrete produced. A lower water-cement ratio leads to higher strength and durability, but may make the mix more difficult to place. According to Rakennustekniikan koulutusohjelma (2010), water-cement ratio is a very important factor in concrete production, and it has crucial effects to both, fresh and hardened concrete properties. A difference in water amount as small as 5 kg/m3 can cause tremendous effects to workability of fresh concrete. The main variation in water amount comes from the aggregates, and aggregate moisture contents may vary due to the fact that aggregates from a new delivery with different moisture content are used. Also during wintertime when the aggregates are heated in order to get warm concrete, the aggregate mass can locally differ in temperature and moisture content affecting the workability of the concrete.

2.8 CURING PROCESS

Curing is the name given to the procedures used for promoting the hydration of the cement, and consists of a control of temperature and of moisture movement from and into the concrete. Curing allows continuous hydration of cement and consequently continuous gain in the strength, once curing stops strength gain of the concrete also stops. Proper moisture conditions are critical because the hydration of the cement virtually ceases when the relative humidity within the capillaries drops below 80%. With insufficient water, the hydration will not proceed and the resulting concrete may not possess the desirable strength and impermeability. The continuous pore structure formed on the near surface may allow the ingress of deleterious agents and would cause various durability problems. Moreover due to early drying of the concrete micro-cracks or shrinkage cracks would develop on surface of the concrete. When concrete is exposed to the environment evaporation of water takes place and loss of moisture will reduce the initial water cement ratio which will result in the incomplete hydration of the cement and hence lowering the quality of the concrete. Various factors such as wind velocity, relative humidity, atmospheric temperature, water cement ratio of the mix and type of the cement used in the mix will affect the curing of concrete. Evaporation in the initial stage leads to plastic shrinkage cracking and at the final stage of setting it leads to drying shrinkage cracking (Yash Nahata et al., 2013).

Curing of the concrete is also governed by the moist-curing period, longer the moist-curing period higher the strength of the concrete assuming that the hydration of the cement particles will go on. Curing has a strong influence on the properties of hardened concrete; proper curing will increase the durability, strength, volume stability, abrasion resistance, impermeability and resistance to freezing and thawing (Yash Nahata et al. 2013).

According to Yash Nahata et al. (2013), there are three method of curing, air curing, water curing and saturated wet covering. Air curing is a curing method wherein the concrete cubes are left in open air to be cured at room temperature, water curing is a curing method wherein the concrete cubes were cured in water tank at room temperature, and saturated wet covering is a curing method wherein moisture retaining fabrics such as burlap cotton mats, gunny bag and rugs are used as wet covering to keep the concrete in a wet condition during the curing period.

2.9 OIL PALM

Figure 2.3 shows the oil palm and also known as Elaeis guineensis Jacquin, was first introduced into Malaysia in 1870, through the Botanic Gardens in Singapore, while the oil palm industry was introduced to Malaysia in 1917 (Elham P. B, 2001). According to Elham P. B, (2001) also, currently, there are about 326 oil palm mills in Malaysia with a total production more than 8.32 million tonnes per year. Then, there are about 45 palm oil refeneries in Malaysia with a total capacity of 12.73 million tonnes crude palm oil per years and Malaysia ranked as the world's largest producer and exporter of palm oil. The oil palm fruit produces two distinct oils which are palm oil and palm kernel oil. Palm oil is obtained from the mesocarp while palm kernel oil is obtained from the seed or kernel. Palm oil is used mainly for the production of margarine and compounds in cooking fats and oils and also for the production of candles, detergents, soap and cosmetic products. Production of palm kernel oil is about 12% of the production of its palm oil (N. Abdullah and F.Sulaiman, 2013).

Figure 2.3: Oil Palm

Figure 2.4 shows the past and forecast oil palm acreage in Brazil, Malaysia and Indonesia which are from year 1970 until year 2020. The statistic shows the oil palm will increase dramatically by year. Oil palm is the most important product of Malaysia that has helped to change the scenario of its agriculture and economy. The Malaysian government is fully committed to the expansion of the industry and encourages global expansion of palm oil production. Palm oil is now readily accepted globally and Malaysia has exported palm oil to more than 140 countries in the world. The success of the Malaysian palm oil industry is the result of the ideal climatic conditions, efficient milling and refining technologies and facilities, research and development, and efficient and adequate management skills. Practically all palm oil mills generate their own heat and power through the co-generation system (N. Abdullah and F. Sulaiman, 2013).

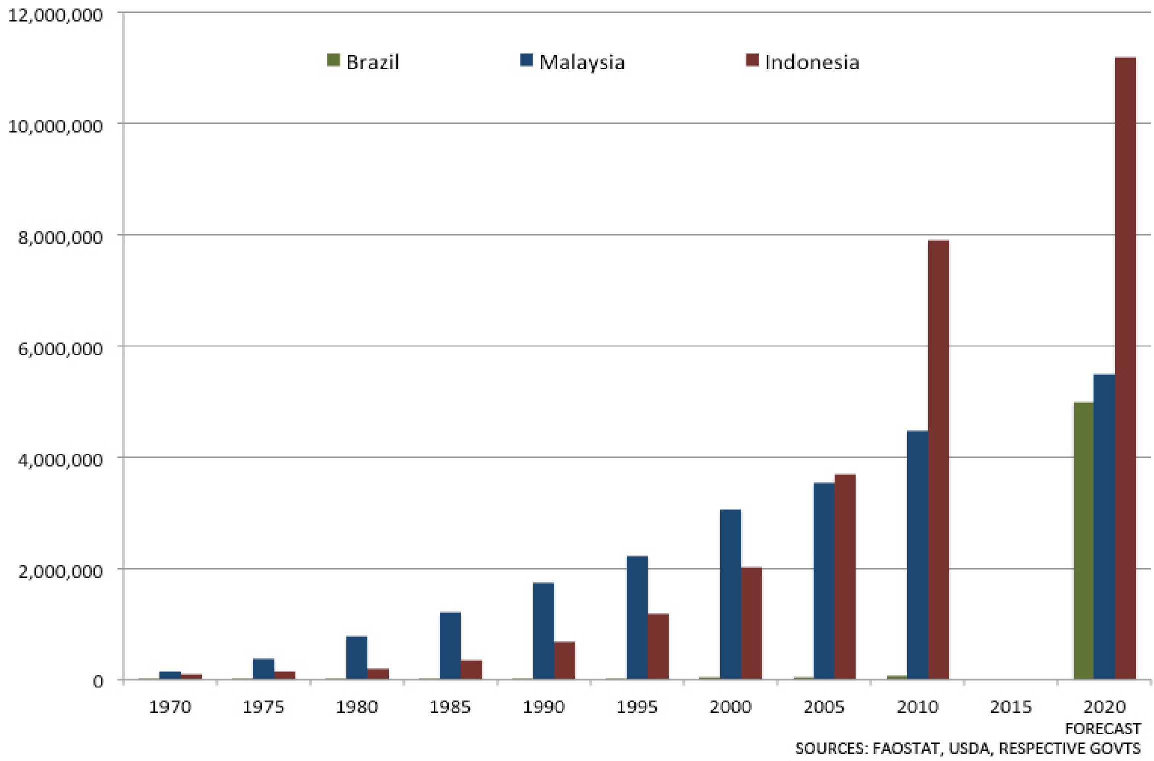

Figure 2.4: Past and Forecast Oil Palm Acreage (ha)

Source: N. Abdullah and F. Sulaiman, (2013)

The fact is the industry has an impact on the environment issues which cannot be denied. The palm oil mill generally have excess fibre and shell which are not used and to be dispose of separately otherwise contribute to environmental pollution (Elham, 2001). Figure 2.5 shows simplified process flow diagram of an oil palm mill which palm kernel shell were produced about 11.5% from a fresh fruit bunches after they were process. Referring to Figure 2.5, as the fresh fruit bunches reach the processing plant, the sterilization process begins with the steam temperature at 140°C, pressure at 2.5 to 3.2 kg/cm2 for 50 minutes. After this process, the stripping process will take over. In the stripping process, a rotating divesting machine is used to separate the sterilized oil palm fruit from the sterilized bunch stalks. The empty fruit bunches (EFB) will fall in the collector and are brought to the burning place as a fuel. After the fruit bunches have been stripped, the sterilized fruits are fed into a digester where water at 80°C is added. This is performed in steam heated vessels with stirring arms, known as digesters or kettles. The most usual method of extracting oil from the digested palm fruit is by pressing. Then, Centrifugal and vacuum driers are used to further purify the oil before pumping it into a storage tank. When the digested fruit is pressed to extract the oil, a cake made up of nuts